‘Mathematics Made No Contribution to the Public Weal’

Citation for published version:
Henry, J 2011, ''Mathematics Made No Contribution to the Public Weal': Why Jean Fernel (1497–1558) Became a Physician', *Centaurus*, vol. 53, no. 3, pp. 193-220. https://doi.org/10.1111/j.1600-0498.2011.00234.x

Digital Object Identifier (DOI):
10.1111/j.1600-0498.2011.00234.x

Link:
Link to publication record in Edinburgh Research Explorer

Document Version:
Peer reviewed version

Published In:
Centaurus

‘Mathematics made no contribution to the public weal’:

Why Jean Fernel (1497-1558) became a Physician

[*Centaurus*, 53 (2011), pp. 193-220.]

Introduction

The historiography of the Scientific Revolution has always recognised the importance of mathematics in re-shaping natural knowledge and the practices associated with it during the late Renaissance and early modern periods. The historians of science who first forged the notion of a Scientific Revolution tended to interpret the historical developments in terms of elite natural philosophers (or even just “scientists”) recognising the importance of mathematics and deliberately introducing it into their attempts to understand the natural world. More recently, however, historians have realised the importance of a fairly extensive array of different mathematical practitioners, and have tended to see the Scientific Revolution as resulting from their innovations in both theory and practice. Mathematicians, not natural philosophers, showed the way to using mathematics in the understanding of the world.[1]

This recent work marks an important historiographical development, which has undoubtedly added to our understanding of the development of early modern attempts to establish knowledge of the physical world, and the best methods of discovering that knowledge. As such, it is a vast improvement on the earlier historiography. It seems to me, however, that the new historiography is tainted with some of the flaws inherent in the earlier historical accounts. Pioneers such as Alexandre Koyré, A. Rupert Hall, R. S. Westfall, and others, tended to give a teleological account, coloured by their knowledge that mathematics is such a crucially important part of the physical sciences of our day. Since every modern scientist knows that mathematics is important, the historiographical argument seemed to run, an innovatory scientist in the past would have recognised it too (and in so doing would have confirmed his genius, and the fact that he was "ahead of his time"). In this kind of historical scenario, Galileo and Kepler were portrayed as physicists who recognised for the first time that physics should be firmly based on mathematical analysis of the natural world. Clearly, we've come a long way since then, and there is no denying the richness and nuanced authenticity of the history revealed in the more recent historiography. Even so, there seems to be a tendency among early modern historians of the physical sciences to regard the rise of mathematics, once its relevance was recognised, as inevitable and inexorable. Historiographical teleology and presentism still linger.

Part of the aim of this paper is to counter this tendency by reminding ourselves of the difficulties that lay in the way of the 'mathematization of the world picture'. Far from being inexorable, or inevitable, there were many obstacles in the way that might have undermined the enterprise of mathematical physics altogether, and certainly delayed what we might regard as its eventual triumph by a couple of centuries. The mathematization of the world picture was a long and slow process. But this is not to say that the Scientific Revolution also had to mark time, so to speak, until non-mathematicians were made to realise the importance, indeed the indispensability, of mathematics. I am *not* offering here an explanation of why the 'Revolution' took such a long time to be accomplished (much less suggesting that the delay was entirely due to opposition to mathematics). Rather, my point is that there was much more to the Scientific Revolution than the mathematization of the world picture. And I do not mean by this simply to point out the obvious fact that there were also contemporary innovations *outside* the physical sciences. We need to bear in mind that, before the mathematization of the world picture, there was a majority of natural philosophers who believed that mathematics was not relevant to, much less necessary for, an understanding of the physics of the world. For such thinkers, the process of reforming scholastic natural philosophy, even in those parts of it which we would characterize as the physical sciences, could proceed perfectly well without any help from mathematics. Indeed, they had very good reasons for supposing that, if the reform of natural philosophy was to succeed, it must do so without making any diversions into the realm of mathematics.

This is precisely why historians of the Scientific Revolution have found themselves turning from natural philosophers to mathematicians in order to understand developments. Only mathematicians saw the importance of mathematics, but they did not have it all their own way. On the contrary, many natural philosophers either dismissed the relevance of mathematics, or simply failed to regard it. I have argued elsewhere that the claims in recent historiography that early modern mathematicians were chiefly responsible for introducing the experimental method into natural philosophy have been overstated (Henry, 2011). In this paper, I want to address the assumption, explicit or implicit in modern accounts, that mathematics was recognised in the early modern period, as it is today, as inherently useful. In fact, the usefulness of mathematics was by no means apparent, even to the learned, in early modern Europe. For a complete understanding of the mathematization of the world picture, we need to look not just at the mathematicians, but at those who had little regard for mathematics.

I want to illustrate this by considering a single case study, although I will try to use it to make some more general observations. The case study concerns the eventual career choice of a would-be mathematician, by the name of Jean Fernel. This is, indeed, the same Jean Fernel now known to history as one of the most innovatory and influential medical thinkers of the sixteenth century. Biographical evidence suggests, however, that Fernel tried to make a name for himself, and a living, as a mathematical practitioner, before he completely abandoned mathematics for medicine. Fernel's achievements as a mathematician were not inconsiderable, but they have attracted scant scholarly attention. Another aim of this paper, therefore, is to consider for the first time, Fernel the mathematician.

The major source of information about Fernel's life and work (apart from Fernel's own writings) is a short biography written by his secretary for the last ten years of his life, the physician and humanist scholar Guillaume Plancy (1514–*ca*. 1568), who had previously been a student of the French humanist scholar Guillaume Budé, and had worked with him until his death in 1540.[2] Although the best source, Plancy's *Vita* is by no means impeccable, and shows some inconsistencies; it is important, therefore, before going any further, to be aware of its shortcomings.

Plancy wrote the biography after Fernel's death, but we do not know how long after. Plancy was definitely dead by 1574, and was reported to have died in 1568. His life of Fernel was not published until 1607, and there is evidence that Plancy had not properly refined and finished it, and that the manuscript from which it was published was in poor physical condition (Sherrington, 1946, pp. 147-50). But, even if we assume Plancy wrote the biography in 1558, it is clear that he did not have first hand knowledge of Fernel's life before he began to work for him, in about 1548. In what follows, we are chiefly concerned with the period from about 1524 to 1530. The account of this period (as we shall see) includes some notable personal details of Fernel's working and family life, but we have no way to check these against any other source.[3] It seems unlikely (being too impertinent and disrespectful) that Plancy would have fabricated his own account of these matters, but it is important to bear in mind that what he wrote was based on Fernel's recollections of a period many years before, and must inevitably have been coloured by Plancy's own preoccupations.

For our purposes, however, the important aspect of Plancy's account of this early part of Fernel's career is the attitude to mathematics that it displays. It seems to me that, even if (as seems likely) this aspect has been embellished by Plancy's own scant regard for mathematics, it was *not* gratuitously intruded into the biography by Plancy. In what follows, therefore, I shall assume that Plancy's *Vita* gives a fairly honest account of these episodes in Fernel's life. But even if this is not the case, and Plancy offers in these parts of the *Vita* what we would consider to be a largely fictionalised account to enable him to promote his own anti-mathematical stance, it does not undermine my point. Either way, the case study shows anti-mathematical attitudes; as held by Fernel's family (and conceded by Fernel himself) in the 1520s, or as held by Plancy sometime in the period between 1558 and 1574 (to say nothing of the opinions held by the several publishers who included the *Vita* in successive editions of Fernel's *Universa medicina* from 1607 to 1680) (Sherrington, 1946, pp. 149-50).[4]

Jean Fernel, mathematician

Jean Fernel became one of the most historically significant medical thinkers of the sixteenth century. At a time when severe cracks were beginning to show in the edifices of both Galenism, and the Aristotelian natural philosophy with which it was so closely linked, Fernel was one of only three thinkers who tried to develop a revised system of medical theory.[5] The other two would-be reformers were Paracelsus, leading promoter of iatrochemistry, and Girolamo Fracastoro, the author of *De* *contagione* (1546), in which discussion of the causative "seeds" of disease has often been seen as a foreshadowing of germ theory.[6] Historiographically speaking, therefore, Fernel is in distinguished company.

This portrait of Jean Fernel, which first appeared in his *Medicina* (Paris, 1554), sig. *iii*v*, is the only known contemporary likeness.

The son of a successful furrier and innkeeper, Fernel was born at Montdidier in the diocese of Amiens, and although he moved with his family to Clermont, near Paris, when he was twelve years old, he always designated himself as 'of Amiens' (*Ambianus*). He took a Master's degree from the Collège de Ste Barbe, of the University of Paris, in 1519 and subsequently taught philosophy there while studying for the doctorate in medicine, which he was awarded in 1530. He lectured on Hippocrates and Galen at the Collège de Cornouailles for six years until his medical practice became so successful that he was forced to give up teaching. It was at this time, however, that he wrote the work (completed by 1538) which he later published as *De abditis rerum causis* (1548; Fernel, 2005). This offered a new theory of contagious and pestilential diseases, which had always been anomalous with regard to ancient theories of disease. Fernel's new theory moved closer to what historians of medicine, following Owsei Temkin (1977), call an *ontological* concept, rather than a *physiological* concept of disease (in which diseases are regarded as having their own independent existence, as opposed to being merely the result of an imbalance of the four bodily humours). Fernel saw his new theory as additional to, not a replacement for, Galenic theory and accordingly decided to clarify the nature and extent of the standard theory, before publishing his own. The result was the fullest exposition of Renaissance Galenism ever written, the *De naturali parte medicina* of 1542. For subsequent editions Fernel appropriated the term *physiologia* (which then signified the study of nature in general) as the title of this work (Fernel, 2003), and so gave rise to the modern usage of 'physiology' as the study of living systems. Fernel's reputation as a practitioner increased after he succeeded in curing the serious illness of Diane de Poitiers (1499–1566), beloved mistress of Prince Henri (1519–99). At this time, Fernel feigned an illness of his own in order to avoid taking the post of chief physician to Henri, and when Henri became king in 1547 he avoided this post again by saying the position was the hereditary right of Henri's father's chief physician. Fernel ran out of excuses in 1556 and finally accepted the post of royal physician. Fernel attended the king at Calais in January 1557, when Henri brought an end to the English occupation, but he died at Fontainebleau the following year. It should be clear from this brief biography that in his day Fernel was recognised as one of the most successful medical practitioners in Europe, and inspired a group of followers, "more numerous than soldiers from the Trojan horse" (Sherrington, 1946, p. 155; Fernel, 1607, sig. *7*v*) who practised medicine all over Europe.[7] Furthermore, as a would-be reformer of medical theory it seems fair to say that his influence upon his contemporaries was at least as great as Fracastoro's, and even rivalled that of Paracelsus (particularly among more conservative thinkers who found Paracelsianism hard to stomach).

In view of all this, it might seem that Fernel's interest in medicine was bred in the bone, and that his achievement must have been the result of an unwavering commitment to medicine from an early age. In fact, this was very definitely not the case. Although devoted in his youth to assiduous study—so much so that he was only forced to break off his studies when overwork caused him to succumb to a 'quartan fever'—Fernel initially had no thought of any particular career. It was only after the enforced convalescence following this fever, when Fernel was already 27, that he 'began to talk over with his friends the career he should take up' (Sherrington, 1946, p. 151; Fernel, 1607, sig. *4*v*). Rejecting divinity and jurisprudence, Plancy says that he chose medicine. Even then, however, Fernel spent a couple of years devoted to 'studies introductory to medicine', namely philosophy and mathematics. Study for the MD took four years, Plancy tells us, and we known Fernel completed his MD in 1530. It was only in 1526 therefore, at the age of 29, that Fernel took up medicine. Even then, however, Fernel was evidently not fully committed. After the 'first two years of basic work for the doctorate', when many of Fernel's fellow students were awarded 'a first class', Fernel only achieved a second class award. Plancy suggests that this was merely because Fernel, unlike his first class fellows, did not resort to bribes: 'A "first" would assuredly have been granted', Plancy wrote, 'had the furnishing of his purse been equal to that of his head' (Sherrington, 1946, p. 153; Fernel, 1607, sig.sig. *5*r*). There was another significant factor, however, which might explain Fernel's comparative underachievement in medicine. In precisely these first two years of his medical studies, Fernel published three significant mathematical books. In spite of opting *formally* for a career in medicine, it seems that, at the outset of his working life, Fernel wanted nothing so much as to make a name for himself as a mathematician.

Now, in some respects Fernel's simultaneous interest in both medicine and mathematics is not as surprising as it may seem to modern readers. Although these two areas of study now seem widely separated to us, this was certainly not the case in Fernel's time. Although the mathematical *quadrivium* was regarded as propaedeutic to the studies in each of the higher faculties (theology, law and medicine), geometry and astronomy, in conjunction with astrology, continued to be taught at more advanced levels in the faculty of medicine. It was not unusual, therefore, to find the most advanced mathematicians working not in the Arts Faculties but in the Medical Schools.[8] Furthermore, many leading physicians at this time also published works in mathematics. Consider, for example, Alessandro Achillini's *Quatuor libri de orbibus* (Bologna, 1498), Girolamo Fracastoro's *Homocentrica sive de stellis* (Venice, 1538), and Girolamo Cardano's *Ars magna: sive de regulis algebraicis* (Nuremburg, 1545). And let us not forget that even Nicolaus Copernicus was training to be a physician as he began to formulate his reformed cosmology. As Charles Webster has pointed out, 'Leading astronomers and cosmologers of the renaissance were educated as physicians; the two avocations were compatible and partly interchangeable' (Webster, 1982, p. 4).

Furthermore, after the bout of quartan fever which led him to decide upon a career, Fernel could not have formally chosen a career in mathematics if he had wanted to, for the simple reason that there was no such thing as a career in mathematics. As Kirsti Anderson and Henk Bos have recently pointed out, 'mathematicians did not come from a well-defined group that earned their living from mathematics' (Anderson and Bos, 2006, p. 697). Moreover, as Michael Mahoney has insisted, 'one is hard pressed to find even a single, unified discipline of mathematics' (Mahoney, 1994, p. 2). Mahoney himself discerns 'six broad categories' of mathematician: classical geometers, cossist algebraists, applied mathematicians, those artists or artisans concerned with geometrical perspective and other aspects of projective geometry, mathematical magicians, and a group he calls the analysts who emerged a bit later in the early modern period, and who combined geometry and algebraic techniques in problem solving, and shared with the applied mathematicians a concern for pragmatism (Mahoney, 1994, pp. 2-14).

Although there were some opportunities for such practitioners as private tutors, or as professors of mathematics in the universities, neither option was very lucrative. Professors of mathematics were even lower down the academic hierarchies than professors of natural philosophy, who were generally paid much less than professors in the higher faculties. The low status of mathematics in the universities clearly reflected a generally low opinion of mathematics among men of letters; although it was possible to take a degree in the liberal arts, it was not possible to take a degree in mathematics. Furthermore, the teaching of mathematics at university was generally of such a low level that it was not even intellectually rewarding. Consequently, those who did teach mathematics in the university system, seldom made it a lifetime's career; it was much more usually undertaken for a few years only by young men biding their time before making their next career move (either into natural philosophy, or medicine, or perhaps something completely different).[9] This remained true in spite of some notable attempts to reform the university curricula in the sixteenth century. Jesuit colleges elevated mathematics to a much more important position in their curricula, but generally mathematics remained a minor, propaedeutic study in the arts faculties (Mahoney, 1994, p. 12).[10]

Those who did spend their lives working as mathematicians usually did so outside the university system, and either had private means, or were lucky enough to attract the commitment of a wealthy patron. In England, for example, Thomas Harriot and Thomas Digges were able to make life-long careers as mathematicians thanks to steady patronage. John Dee, by contrast, sought the patronage of his Queen, but never succeeded in winning reliable support and had to leave England for patronage abroad. Galileo, managed to escape a poorly paid position as a professor of mathematics at Pisa and subsequently Padua, when he attracted the patronage of Cosimo II de Medici, while René Descartes expressed his gratitude that he never had to earn a living, being sufficiently financially secure that he could always pursue his own ambitions.[11]

In view of all this, then, it might be supposed that Fernel was just another of those medical men who continued to indulge a passion for mathematics, at least in his youth, but that his interest in mathematics was as a mere sideline, and was unexceptionable among university-trained medical men. If we look more closely, however, at Plancy's life of Fernel and at Fernel's three mathematical publications, a rather different picture emerges. Compared to most of his fellow physicians, Fernel's interest in, and commitment to, mathematics was altogether exceptional. So much so that it seems impossible to deny that for a while at least, he seriously entertained ambitions to make a living as a mathematician.

If this is true, however, we need to ask ourselves why Fernel might have opted for this unpromising career choice. After all, as Mahoney has pointed out, in mathematics 'There were no positions to be gained or held. There was no ladder of advancement leading into a hierarchical elite' (Mahoney, 1994, p. 21). What inspired Fernel to think that he might, against the odds, make a living as a mathematical practitioner?

It so happened that mathematics had enjoyed something of a revival in Paris during the opening decades of the sixteenth century. In 1495, seeking to reform the Arts curriculum at the Collège du Cardinal Lemoine, of the University of Paris, the leading French humanist Jacques Lefèvre d'Étaples (*c*. 1455-1536), placed renewed emphasis upon the importance of the mathematical quadrivium. The study of mathematics was subsequently encouraged by his colleagues, Jossé Clichtove (1472-1543), and Charles de Bovelles (1479-1553). Furthermore, these three scholars published between them a considerable number of mathematical works. These included new editions of the arithmetics of Boethius and Jordanus de Nemore, and of the *Sphaera* of Sacrobosco, as well as treatises on geometry, astronomy, music, squaring the circle, doubling the cube, and so forth (Victor, 1978, pp. 36-44).

Furthermore, these three attracted into their circle a student at the Collège de Navarre who subsequently went on to become the leading French mathematician of his generation, Oronce Fine (1494-1555) (Marr, 2009). If his three older mentors were more interested in the mystical side of mathematics (they were interested in the theological use of number symbolism), Fine was much more concerned with the pragmatic aspects of mathematics.[12] Although he too edited earlier works, including Euclid's *Elements* (1536) and Peurbach's *Theoricae novae planetarum* (1525), he was also an inventor of mathematical instruments, a leading cosmographer, and an influential mathematical teacher (including Petrus Ramus among his students). Undoubtedly, as one recent commentator has suggested, Fine was 'one of the progenitors of a French renaissance of mathematics' (Marr, 2009, p. 5). Fine became especially active in publishing mathematical works following his release from a short prison sentence (possibly for charges connected with his practice of judicial astrology) in 1525, and in 1531 he was appointed to the newly established chair of mathematics in the Collège Royal, recently founded by François I (Pantin, 2009). Indeed, the king agreed to create a Royal chair of mathematics, alongside the more obviously humanist chairs of Greek and Hebrew, at the urging of Fine himself, who in an *Epistre exhortative* (1530) extolled the practical usefulness of mathematics and claimed that a chair of mathematics would lead to France 'surpassing in sciences' (Marr, 2009, pp. 7-8; Pantin, 2009, p. 17).

In view of this background, it is easier to understand why a brilliant young man, whose friends felt he could make a successful career in any of the three traditional professions, divinity, law, or medicine, might have harboured ambitions instead of forging a career in mathematics. Indeed, Plancy even records that, after his episode of quartan fever, when Fernel 'began to talk over with his friends the career he should take up', some of his friends proposed mathematics ('alii mathematicas disciplinas… proponebant') (Sherrington, 1946, p. 151; Fernel, 1607, sig. *4*v*). If we can assume that this is an accurate report, and a career in mathematics really was suggested by some of Fernel's friends, it surely counts as testimony to the respect for mathematics in contemporary Paris, following the reformist educational schemes of Lefèvre d'Étaples and his circle, and the urgent activities of Fernel's almost exact contemporary, Oronce Fine.

Be that as it may, Plancy, having no interest in, and presumably therefore no knowledge of, this burgeoning of early sixteenth-century French mathematics, simply tells us that Fernel became determined to master mathematics:

> he was unskilled in mathematics, so that he would stumble over examples commonly given by authorities in their exposition (of the subject); he felt it a scandal to be ignorant in a field of learning, which he admired no less than any other. So it was that he set out to cultivate his mind systematically, apportioning distinct and separate periods to his several studies. He gave the morning to arithmetic and mathematics; after the midday meal he turned to natural philosophy, and after supper to the Latin classics, paying special attention to their style (Sherrington, 1946, p. 151; Fernel, 1607, sig.sig. *4*v*).

The liberal arts consisted of seven subjects, grouped as a foursome and a triad. Fernel's day, it seems, was divided into studying the mathematical subjects of the quadrivium (arithmetic, geometry, astronomy, and music—essentially the mathematics of proportions) in the morning, and the trivium of linguistic studies (grammar, logic and rhetoric) in the evening. The afternoon was devoted to the natural philosophy of Aristotle which had long since become the mainstay of the university Arts curriculum, additional to the seven liberal arts.

According to Plancy, at this time Fernel 'thought every hour lost which was not spent in reading and studying', but his father, having seen Fernel through his university education to the MA, felt that he could no longer justify (to the rest of the family) paying for Fernel's private studies (Sherrington, 1946, p. 151; Fernel, 1607, sig. *4*r*, and p. 152; Fernel, 1607, sig*4*v*). It was at this time (coinciding with the quartan fever that allegedly prompted him to consider his future) that Fernel decided to train as a physician. But, now having to pay his own way, he took a post as a lecturer in natural philosophy at the College of Ste Barbe in Paris. Moreover, Fernel did not abandon his mathematical studies, in order to make way for his medical studies. Indeed, if anything Fernel became much more focussed upon mathematics than on anything else. This is evident from the biography which describes an extraordinary commitment to mathematics in Fernel's daily life at this time.

Fernel had recently married and, using money from his wife's dowry, he began to build up a collection of 'the writings of all the old mathematicians'. But he did not stop there. He also built up a collection of astrolabes and other bronze mathematical instruments, many of which he had devised himself, and all of which were, as Plancy wrote, 'costly'. What would undoubtedly have added to the cost was the fact that Fernel employed craftsmen and engravers to make these instruments for him, and they lived in the Fernel household. To off-set these expenses he gave lessons in mathematics to a number of 'distinguished pupils', and tried to earn money as a writer of mathematical treatises, and presumably by selling at least one of the mathematical instruments he invented, the so-called 'monalosphaerium'. Indeed, his first book was an instruction manual for this instrument (Sherrington, 1946, pp. 153-54; Fernel, 1607, sig. *5*v*-*6*r*; Fernel, 1527).

He also used the opportunity in his publications to ingratiate himself with potential patrons. He started, in his first publication, with Jacobus Govea, whom Fernel describes as 'highly numerate and a renowned doctor of theology', addressed the next to Johannes III, King of Portugal, and dedicated his final mathematical treatise before he committed himself to a medical career, to a Frenchman who acted as a patron to learned men, Martin Dolet.[13] It seems clear that Fernel thought his best chance of a paying career in mathematics was through the newly burgeoning field known as cosmography. Accordingly, he dedicated the first two of his mathematical books to likely representatives of the greatest sea-faring nation at the time, Portugal.

Jean Fernel, cosmographer

The period from 1490 to 1510, the period of the first major voyages of discovery, has recently been seen as marking a 'cosmographic revolution' (Vogel, 2006, p. 476). When Ptolemy's *Geography* was first translated into Latin in 1406, the translators, Manuel Chrysolaras and Jacopo d'Angelo, chose to translate the title as *Cosmography*. Ptolemy's work, as might be expected from the author of the *Almagest*, was a mathematical treatment of various aspects of the Earth, including techniques for making map projections, the imposition of lines of latitude and longitude, and so forth. In some cases Ptolemy's account required an understanding of the vault of the sky and its projection onto the surface of the Earth, and as such the book dealt with the whole world, or universe, not just the earth, and so 'cosmography', the translators argued, was a more fitting title than 'geography' (Mosley, 2009, p. 425). Ptolemy's *Cosmography* was first printed in 1475, and subsequently appeared in at least six editions before 1490.

One of the important aspects of Ptolemy's work was that it assumed that there was one single globe of earth and water—a terraqueous globe. This, together with the experiences reported by those who undertook the various voyages of discovery, led to the final dismissal of an influential alternative view. The alternative, promoted by scholastic natural philosophers and supposedly based on abstract philosophical considerations derived from Aristotle, held that the sphere of the Earth was floating in a larger sphere of water, with only part of its top hemisphere above the surface of the water. Although the Ptolemaic view was held by a number of thinkers before this period, the final dismissal of the scholastic view can indeed be held to be a cosmographic revolution (Randles, 1993; Vogel, 2006). Although cosmography subsequently developed in a number of different ways (Mosley, 2009), it certainly led to a new field of applied mathematics, and seemed to offer new opportunities to men like Oronce Fine and Jean Fernel. It is hardly surprising, therefore, that Fernel should try to master this new cosmography. Certainly, Fernel's first two mathematical books mark their author out as someone with great ambitions as a cosmographer.

Fernel's first publication, *Monalosphaerium, partibus constans quatuor*, as the title made clear, was specifically concerned with describing his newly invented 'monalosphaerium' and instructing the reader in its various uses. Fernel's instrument was essentially an astrolabe which managed to project all the information provided in different inscribed sections of an astrolabe on to one circle. He admitted its similarity to an astrolabe but believed it was an improvement upon the traditional instrument because it was equally comprehensive, but more convenient in use (Fernel, 1527, sig. Avi*r*). The altitudes of the Sun, Moon and stars could be read from the monalosphaerium, and the lunar cycle derived from it. Thanks to inscribed coordinates of latitude and longitude of major cities, the latitude and longitude of any place could be found, and distances from one place to another. It was also useful, at least on a starry night, for giving the time in 'equal hours', and could be used to proceed from equal hours to unequal, and vice versa (Fernel, 1527, ff. 5*r*, 18*r*). And, of course, it could be used as a perpetual calendar, particularly for calculating Easter and other moveable feasts (Fernel, 1527, f. 7*v*). Fernel also showed how it could be used for determining the critical days in various fevers, and for drawing up horoscopes.

For good measure, Fernel provides a fourth and final part to the book which bears little relation to the first three parts, but which shows the reader how to calculate various things, such as the height of a tower, the distance between two places, and the depth of a cistern. The work closes with some discussion of the measurement of areas, and how to relate the area of a triangle to that of a square, or even to the volume of a cube. This section seems to provide Fernel with the opportunity of showing what he himself can do as a mathematician, after previously confining himself to describing the monalosphaerium, since he declares himself to be now off the leash (Fernel, 1527, f. 25*r*).

In the dedication, Fernel says that he wrote the work in response to Jacques Govea's request for a work that would enable the young to pluck attractive blooms, and other resources from the mathematical disciplines, and thus adorn the rest of the arts, as if with jewels: 'For mathematics is of a nature to bring lustre to tired topics, and to keep a mind in one's body that is imbued with incredible life-long pleasure' (Fernel, 1527, sig. Avi*r*). Although Govea, who later became Rector of the College of Ste Barbe, was only at the beginning of his career there when Fernel dedicated the book to him, he already had the ear of the King of Portugal and that would be enough for Fernel to want to cultivate his friendship. Fernel tells us in the dedicatory epistle that after charging him with this duty to the young, Govea left Paris to visit the King of Portugal. Perhaps Fernel hoped that important French readers might be spurred into making sure that Fernel should continue to work for French maritime interests, rather than be tempted away by the attentions of the Portuguese (Sherrington, 1946, p. 172).

Be that as it may, Fernel aimed at the top of the Portuguese tree with his next, and surely most important, work, *Cosmotheoria*. He dedicated this to the King of Portugal himself, João III (Fernel, 1528a)). Not knowing the King personally, he resorted to praising the achievements of renowned Portuguese explorers, from Henry the Navigator (1394–1460), and Bartolomeu Dias (*c*. 1450–1500), the first European to round the Cape of Good Hope (1488), while searching for the legendary Christian kingdom of Prester John, to Paulo (*d*. 1499) and Vasco da Gama (*c*. 1469–1524), who extended these explorations to find a route to India (Fernel, 1528a, sig. Avi*r*-*v*).

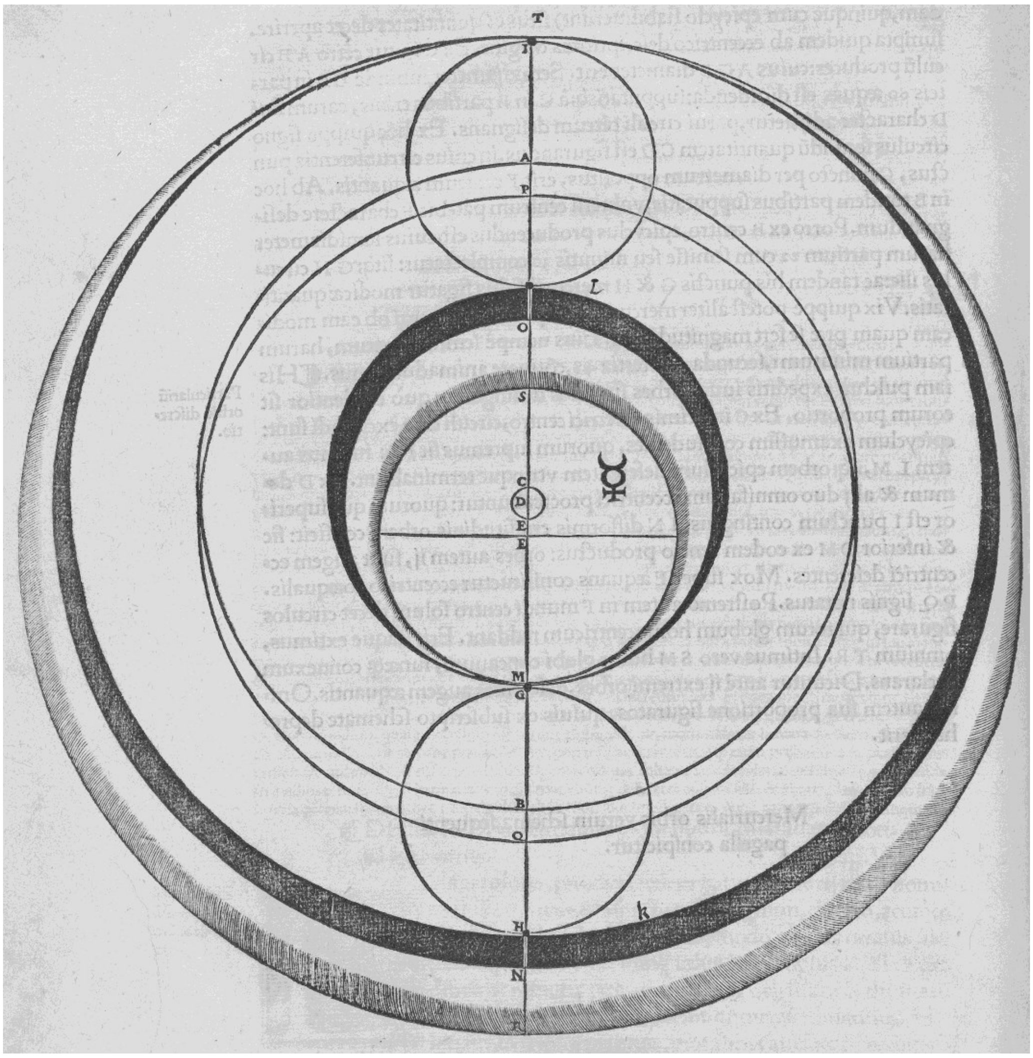
Clearly, Fernel was attempting to flatter the King by association. Fernel did not rely solely on flattery, however. He clearly hoped that the practical usefulness of the information provided in *Cosmotheoria*, would be immediately recognisable to the king and his advisers, and would therefore attract patronage.[14]

The main theme of the *Cosmotheoria* is the size of the Earth and of the heavenly spheres. But right at the outset he rejects the scholastic view of the floating Earth partially protruding from a separate sphere of water, and affirms the Ptolemaic view that the earth and seas form a single globe. 'One must thus agree', he wrote, 'that the earth looks like a wooden globe in which there are many hollows in which water can gather' (Fernel, 1528a, sig. B*v*; Randles, 1993, pp. 67-9). It is perhaps this aspect of Fernel's second book which has led a leading historian of cosmography to describe it as 'one of the most original contributions to cosmography in the French Renaissance' (Randles, 1993, p. 67). As a measure of the importance of this issue, it can be noted that Copernicus also discussed the same matters in Book 1, Chapter 3, of his *De revolutionibus* (1543), 'How Earth forms a single sphere with water'. Indeed, it has been suggested that the confirmation of the Ptolemaic single globe of earth and sea by the Renaissance voyages of discovery were what made it possible for Copernicus to develop his theory of a planetary (wandering) Earth.[15]

Fernel's *Cosmotheoria* is also famous for the attempt to establish the length of a degree of a great circle of the Earth. Taking with him a reliable clock, Fernel travelled due north (or nearly due north) of Paris until he found the place where the elevation of the Sun at noon corresponded to one degree north (presumably this took a few days to establish). He then returned to Paris by coach and counted the number of times one of the coach wheels made a full revolution. Knowing the circumference of the wheel, he was able to calculate the full distance. Given the fact that Fernel counted 17,024 revolutions of the wheel, there was some room for error. It is a testimony to the care with which he undertook this measurement, however, that the surprising accuracy of his result continued to impress subsequent investigators and commentators (Fernel, 2005, p. 10). Fernel declares the length of a degree of a great circle of the Earth to be 700 stadia, or 87½ Italian milliaria. But he then tries to help the reader to be able to understand these lengths in their own local terms. He starts with a *digitus*, which he says is the length of four grains of barley. Four *digiti* are a *palmus*; four *palmi* make a *pes*; and a cubit is one and a half *pedes*, or six palms. He then arrives at a measure for a *passus geometricus* of five *pedes*. The Italian stadium is 125 *passus*, and an Italian *milliarium* is eight *stadia*, or one thousand *passus*. A German *milliarium*, however, has 4000 *passus*, and the Swedish variety has 5000 (Fernel, 1528a, f. 2*r*).

Having dealt in the first chapter with the size of the Earth, Fernel went on to discuss the dimensions of the sphere of air, and the sphere of fire, before dealing with each of the heavenly spheres in turn, including the sphere of the fixed stars, and the *primum mobile*. Although primarily concerned with the physical dimensions of the spheres, Fernel also considers the sizes of the circles (deferents and epicycles) assumed by astronomers in accounting for the precise motions of the heavenly bodies. There is nothing particularly new in the general approach, since it is based on the standard assumption that the heavenly spheres are nested contiguous with one another, and is in keeping with Peurbach's *Theoricae novae planetarum* (1454, published posthumously, by Regiomantanus, in 1472). Clearly, however, Fernel was convinced that he was offering a new and more accurate assessment of the heavenly dimensions.[16] It seems reasonable to suppose that Fernel believed that an accurate idea of the relevant dimensions would facilitate much needed improvements in astronomy. It should not be forgotten that Fernel was writing not long after Copernicus had written his *Commentariolus* (*ca*. 1512), the first unpublished account of his heliocentric astronomy (and known only to a few, which did not include Fernel) (Copernicus, 1985, pp. 81-90). This was a time, therefore, when astronomers were casting around for a way to improve the principles of their art. Evidently, Fernel did not have Copernicus's creative flair (not in astronomy, anyway—it would be a different matter when he finally turned to medicine), but by emphasising the improved accuracy of his measurements and calculations he was in good company. Even half a century later, Tycho Brahe (1546–1601) was pinning his hopes for the future of astronomy on more accurate assessments of planetary movements, rather than on the more drastic Copernican reforms (Thoren, 1990).

Fernel's third, and final, mathematical treatise is rather different from the other two. Instead of focussing upon astronomical or cosmographical matters, it takes a much broader approach, seeking to show the value of mathematics in a number of different areas. Also, it is not dedicated to a potential Portuguese patron, but is dedicated to the now highly obscure Martin Dolet. It is possible that Fernel saw Dolet as a likely patron himself, or perhaps Dolet acted as a patronage broker. Fernel describes him in the dedication as a 'most devoted patron and protector of learned men' (Fernel, 1528b, sig. Aiiii*r*). Perhaps Fernel sensed that he was not going to succeed in attracting Portuguese patronage, and felt that broader claims about the usefulness of mathematics, rather than a focus on cosmography, were required if he



	partes semidiametri eccẽtrici	m	2	Semidiameter terræ	m	2	Milliaria Italica	passus
E P,vel E Q,æquantis semidiameter.	60	0		117	2		456430	
C B,eccentrici semidiametri tanta	60	0		117	2		456430	
F E,& E D,& D C,eccentricitatum quælibet.	3	0	0	5	51		22815	
B G,epicycli semidiameter.	22	30		43	53		171145	
G M,corporis mercurij semidiameter.	0	1	6	0	2	8	138	666 2/3
Mercurialis corporis diameter.	0	2	12	0	4	16	277	333 1/3
F M,vel F S,concaui totius semidiameter.	33	2	54	64	27	32	251439	666 2/3
F G,à mũdi medio ad ☿ centrũ dũ est in maxima vicinia.	33	4	0	64	29	40	251528	333 1/3
F A,longitudo remotior.	69	0	0	134	35	0	524875	
F B,longitudo propinquior.	51	0	0	99	29	0	387985	
F I,à mũdi medio ad ☿ cẽtrũ dũ est in maxia remotione.	91	30		178	28		696020	
F T,vel F R,totius globi conuexum.	91	31	6	178	30	8	699158	666 2/3
S T,vel M R,exacta totius globi crassitudo.	58	26		114	2	36	444769	
A B,eccentrici diameter.	120	0		234	4		912860	
G H,epicycli diameter,ac eccentrici crassitudo.	43	0		87	46		342290	

Fernel’s depiction of the sphere of Mercury, and table showing the various dimensions of different aspects of the sphere, including the epicycle and the body of the planet. From Fernel, *Cosmotheoria*, f.12*v* and f. 13*r*. with acknowledgement to Edinburgh University Library, Special Collections Department, Df.1.18/3.

was to have any sway with French patrons. *De proportionibus*, accordingly, is concerned with the proposition that 'everything in nature (how much more so, in people and in medications) is created in a fixed proportion of components'. It was for this reason, Fernel says, that the 'ancient philosophers' believed 'harmony is the sole principle of all things' (Fernel, 1528b, sig. Aiiii*r*).

Fernel describes the mathematics of proportions as 'a weapon considerably concealed', because of the difficulty of using it, but which can be used in many different spheres. Ethical philosophy, he claims, deals with things which are so inextricably linked that only the theory of proportions can sort them out. Here he is drawing upon the suggestion of mathematically inclined humanists that music, as the discipline of proportions and balance, offers a science of the good life. The theory of proportions was seen, therefore, as an important *scientia activa*, essential for understanding both moral and political science.[17] Similarly, even the study of the pulse in medicine relies upon a theory of proportions, we are told, since Galen attributed the pulses to musical harmonies in the body.[18] There is, in short, Fernel says, a diverse harvest to be reaped, from geometry and astronomy to natural philosophy, and beyond.

In view of all this, it could hardly be said that Fernel had merely a dilettante's interest in mathematics, or that his interest in mathematics went no further than that of other physicians. On the contrary, it seems impossible to deny that he was aiming to establish himself as a member of what he perhaps saw, in the period immediately following the revival of mathematics by Lefèvre d'Étaples and his circle and reinforced subsequently by Oronce Fine, as a growing community of vocational mathematical practitioners. Furthermore, in view of the nature of his publications and his attempts to win patronage for the kind of work detailed in them, it seems likely that he harboured genuine ambitions to establish himself as a leading cosmographer. The fact that he was producing his mathematical works while working towards his MD should not be seen as diminishing his separate commitment to mathematics.

Jean Fernel, mathematician manqué, and physican

Why, then, did Fernel abandon mathematics and turn his attention entirely to medicine? After publishing his *De proportionibus* in 1528, Fernel never again wrote a mathematical work. All his subsequent publications were medical and, unlike his mathematical writings, they immediately established Fernel's reputation as a leader in the medical arts and sciences. Furthermore, by the time his first medical publication appeared, the *De naturali parte medicina*e, in 1542, Fernel had long since sold off his collection of mathematical books and his collection of instruments. He had dismissed the instrument makers and engravers he had employed and housed, and he had notified his private mathematical pupils that 'they must look elsewhere for a master' (Sherrington, 1946, p.154; Fernel, 1607, sig. *6*v*). What caused this dramatic change of direction?

The answer is very clear in Plancy's account of Fernel's life. It was apparent to Fernel's family, and in particular to his wife and his father-in-law, who lived in Paris and 'often saw his son-in-law', that Fernel was not making a suitable living out of his pursuit of mathematics. On the contrary, Fernel was 'dipping into his wife's marriage portion' to fund his expensive indulgence in mathematics. Plancy hints at a domestic scene in which Fernel's wife became increasingly distressed by the financial hardship into which Fernel seemed to be leading her and their two daughters. Whenever Fernel's father-in-law came to visit,

> he would take occasion to complain to his son-in-law that medicine, which had been his whole devotion formerly, now concerned him too little. He so clung to mathematics that neither love of his wife, nor the endearments of his children, nor the care of his house, could take him off them (Sherrington, 1946, pp. 153-4; Fernel, 1607, sig. *5*v*-*6*r*).

Eventually matters came to a head and Plancy tells us that the father-in-law, 'moved by his daughter's tears, lost his temper and scolded his son-in-law.' It was as a result of these 'entreaties and reproaches' that 'Fernel gave way at last' and 'renounced his mathematics and began to devote himself to medicine with a greater zeal than ever before' (Sherrington, 1946, p. 154; Fernel, 1607, sig. *6*v*).[19]

It is perhaps worth remarking that the family's concern about the comparative earning power of mathematics and medicine was surely vindicated. Long before the end of his life, Fernel's earnings as a physician turned him into a wealthy man. As Plancy tells us, and this time he has first-hand knowledge:

> Throughout the time I lived with him (and I lived with him for ten years) his annual income often exceeded twelve thousand French pounds and rarely fell below ten (Sherrington, 1946, p. 170; Fernel, 1607, sig. ***2*v*).

Just three years before this, Oronce Fine had died after enduring years of financial hardship. Dependent on courtly patronage, Fine all too often found himself, in spite of his undeniable achievements, 'waiting and begging for payment for his efforts and being mocked and put off with courtly pittances' (Marr, 2009, p. 9, quoting Fine's son, writing in 1560).

It is evident that Fernel's own efforts to attract patronage repeatedly failed, and his pursuit of mathematics, in spite of his private tutoring, cost him more than it brought in. Sir Charles Sherrington, noting the sumptuousness of Fernel's mathematical treatises, assumed that he must have 'had a generous patron at his back'. Each of the books was evidently published with a separate book of plates (no copies of which are known to survive), so they were clearly expensive to produce.[20] Sherrington's assumption may well be correct but it only makes it more likely, rather than less, that Fernel was hoping to attract further patronage following upon his publications. Alternatively, Sherrington's surmise may be wrong. Given that Fernel does not thank an already generous benefactor in his dedicatory epistles, but merely solicits for future patronage, it seems likely that Fernel actually paid for the printing of these books himself. Fernel is known to have employed his own engravers, and the excellent engraved illustrations in these three books (to say nothing of the lost extra booklets of plates), show every sign of having been closely supervised by the author. Perhaps this is why, as Plancy tells us, Fernel had to dip 'into his wife's marriage-portion' (Sherrington, 1946, p. 153; Fernel, 1607, sig. *5*v*). If so, then he would certainly be hoping that the expenditure on the books would eventually pay dividends by attracting sufficient interest that he might win patronage from them. When all this failed, it must have seemed obvious to everyone around him, and eventually even to Fernel himself, that mathematics was not a good choice of career, particularly if the option of a medical career was open to him.

Fernel and the usefulness (or not) of mathematics

It is possible, however, to discern another important factor in Fernel's decision to abandon mathematics. It is usual in the historiography of mathematics, particularly in accounts of its gradual recognition during the Scientific Revolution as a crucially important way of understanding the world, to emphasise its practical utility. In contrast to the contemplative natural philosophy of the pre-modern world, mathematics was always seen to provide practical information which could be put to use for the benefit of all. Or so the story goes. Plancy's *Life*, however, presents a rather different attitude to mathematics. It seems that the pragmatic usefulness of mathematics was by no means obvious to everyone.

Plancy presents this alternative view of mathematics in a re-imagined quotation from Fernel's father-in-law:

> 'Now, knowledge of mathematics is in itself as culture well enough, and exercises the wits, if one uses moderation in the time given to it. But it becomes a scandal when an honest man with duties to the public and his family reposes, so to say, to sleep on the quick-sands of the sirens, letting the years go by. Mathematics made no contribution to the public weal. Apart from a modicum of arithmetic and geometry it touched society little or not at all. On the other hand when we turn our gaze and thought to medicine we find it a science occupied either with sublime enquiry into Nature or with deeds of beneficence and utility. It is of right the worthiest of all the arts. Mathematics offers no comparison with it' (Sherrington, 1946, p. 154; Fernel, 1607, sig. *6*r*).

It is impossible to tell whether this quotation was reconstructed by Fernel in reminiscence, and told to Plancy while he was gathering information for the *Life*, or whether Plancy himself imagined it as typical of the kind of things any 'man of experience', as Plancy described Fernel's father-in-law, would have said about mathematics. It seems certain, however, that Plancy himself did concur with these views. Immediately after attributing these words to the father-in-law, Plancy says, 'he urged on Fernel these *and other good reasons*.' Furthermore, at this point in his narrative he depicts Fernel's father-in-law not only as a man of experience but also as 'prudent and accomplished' (Sherrington, 1946, pp. 153-54; Fernel, 1607, sig. *6*r*-*v*). This dismissal of the value of mathematics does not emanate from a critic of no standing, therefore, but from a man of supposed worldly wisdom.

There are also echoes of these criticisms of mathematics in Plancy's own comments in the *Life*. Even before recounting Fernel's abandonment of mathematics, Plancy had felt it necessary to apologise to the reader for Fernel's infatuation with the subject: 'Contemplation of the stars and heavenly bodies excites such wonder and charm in the human mind that, once fascinated by it, we are caught in the toils of an enduring and delighted slavery, which holds us in bondage and serfdom' (Sherrington, 1946, p. 153; Fernel, 1607, sig. *5*v*-*6*r*). This foreshadows the comment about sleeping on the quick-sands of the sirens. Similarly, the father-in-law's unfavourable comparison of mathematics with medicine is reflected later in the *Life* when Plancy says that Fernel 'bitterly regretted that he had formerly given himself up' to astrology, if not mathematics more generally.

In what is an unusually long discussion of any one topic in the biography, Plancy first tells us that Fernel came to believe that judicial astrology was 'erroneous and unfounded', before going on to say that he himself was 'entirely at one with the teaching of this great man' on this topic. 'My view', he wrote, 'is that these impostors with their judicial astrology, pressing with extravagant zeal this absurd and ridiculous view of the influence of the stars, outrage both heaven and medicine' (Sherrington, 1946, p. 159; Fernel, 1607, sig. **2*r*).

It is important to note here, however, that Plancy does not object to the idea that the stars can affect things on Earth. His objection is to the claim that knowledge of such things can be discovered through mathematics. Consider, for example, this comment on the cause of pestilence:

> I recognise willingly that often the Divine Power, whose decrees and plans are inscrutable, permits, in punishment of man's misdeeds, and in order to turn man back from his errors, pestilence and contagion, for him to bear. I will not deny even that the stars by their malignity corrupt the air to such a point that it becomes a source of mischief to man and beast, and sows the seeds of death. But I hold that none of these things can be foreseen by help of judicial astrology, and they are known only by their actual event.[21]

The objection is not just to the divinatory aspects of astrology, but to the inadequacy of its causal claims:

> Against the laws of Nature, they view matter as taking exceptional and strange forms, and sublunar bodies undergoing certain changes. They attribute these happenings to the 'aspects' and the 'conjunctions' of the stars (Sherrington, 1946, p. 159; Fernel, 1607, sig. **2*r*).

Conjunctions occur when two heavenly bodies appear close together, or coincident, against the background of fixed stars, and the aspects are particular angular separations of heavenly bodies, such as 60 or 90 degrees, which are supposed to be particularly significant. For Plancy, however, it is clearly an absurdity to imagine that the *geometrical* configuration of the heavenly bodies can have any kind of *physical* effect.[22]

Another factor which prevented educated men from recognising any usefulness in mathematics derived from the strict separation of mathematics from natural philosophy. Deriving ultimately from Aristotle's views, the prevailing view was that natural philosophy was concerned to provide explanations of natural phenomena in terms of physical causes, and that mathematics could say nothing about causes, but could only give a particular kind of *technical description* of what was going on in a physical system. So, a specific set of deferent and epicycle, allocated a specific combination of movements, could show us how the observed movement of a particular planet could be accomplished, but this assumed set-up could say nothing about how or why (or even whether!) the planet moved in this way, or what kept it in these motions. Generally speaking, mathematics was regarded as incompetent with regard to natural philosophy (Dear, 1995; Mancosu, 1996).

The most famous (or, as it is seen in the standard historiography of science, infamous) illustration of the gulf between mathematics and natural philosophy, of course, is the preface added to Copernicus's *De revolutionibus orbium coelestium* by Andreas Osiander, the Lutheran minister who had been delegated to supervise it through the press. As Robert S. Westman has pointed out, Osiander's wording reveals that he was not so much concerned that the nature of the physical world might be thrown into confusion by Copernicus's heliocentric astronomy; rather he was concerned that 'the liberal arts, established long ago on a correct basis, should not be thrown into confusion' (Westman, 1980, pp. 108-9, quoting Osiander). Copernicus was in danger of throwing the liberal arts into confusion because his book might seem to imply that geometrical astronomy could reveal to us the true nature of the World system, whereas, as all educated men knew, only natural philosophy could establish physical truths.[23]

If the recent historiography devoted to uncovering the history of cosmography has correctly recaptured events, it seems that Fernel should be counted as one of those who was convinced of the power of mathematics for deciding upon controversial philosophical matters (in particular the precise arrangement of the sub-lunar spheres (especially the spheres of earth and water), and therefore sought to promote the usefulness of cosmography, even before Copernicus's more powerful version of mathematical realism pointed the way to what has been seen as the 'mathematization of the world picture.' The definitive history of cosmography has yet to be written but its practitioners seem to have developed, even before Copernicus, a mathematical realist view of the world (as opposed to the more traditional instrumentalist view implicit, for example, in Osiander's preface).[24] Moreover, their confirmation of the earth as a single terraqueous globe was an important factor enabling Copernicus to proceed with his own realist astronomy.[25] It is arguable, therefore, that the renewed philosophical debate on the relevance of mathematics to natural philosophy, which emerged at this time, may have had its beginnings in the 'cosmographic revolution', rather than the Copernican revolution. If Osiander was content merely to declaim that the liberal arts had been established 'on a correct basis', there were evidently others, who were willing to discuss the matter, pro and con. [26]

If these debates ultimately led to the recognition that mathematics, far from being excluded from natural philosophy, could, and indeed must, contribute to our understanding of the physical world, it was a long, slow, process.[27] At the time that Fernel was writing his mathematical works, the majority of the inhabitants of the Republic of Letters were unaware of the claims being made on behalf of mathematics and continued to regard it as irrelevant to natural philosophy, and therefore of little or no use to their concerns. We should not be surprised, therefore, much less disappointed, that Fernel the mathematician , who showed in the late 1520s that he did believe in the relevance of mathematics to our understanding of the physical world (not only by his confirmation of the Ptolemaic terraqueous globe, but also by his clearly realist claims about the physical dimensions of the planetary spheres—deferents, epicycles, and all), soon abandoned the idea; or did so to all intents and purposes by abandoning the study and promotion of mathematics itself.

Another contemporary claim in favour of the usefulness of mathematics, which is at least implicit and sometimes explicit in Fernel's three earliest publications, is its use in training the growing mind. It is clear from the lavish nature of his three mathematical books, no less than from their content, that Fernel should be included among the so-called 'mathematical humanists', who wished to elevate mathematics in the disciplinary hierarchy because of its perceived usefulness in pedagogy.[28] We can see this, perhaps, in Fernel's concern that his mathematical book should be accessible to those without much mathematical training. In *De proportionibus*, for example, he tells us that he 'deviated slightly from ancient mathematical practice' so that he could 'put the proofs of what he had to say in few words, to prevent inducing nausea and disgust in people with little mathematical training, who have particularly hated proportions' (Fernel, 1528b, sig. Aiiii*r*). Fernel was among the first generation of mathematicians to begin to exploit the almost complete corpus of Ancient Greek mathematics which had been recovered by humanist manuscript collectors in the fifteenth century. For humanist mathematicians like Leon Battista Alberti (1404-1472), and Luca Pacioli (1445-1517), mathematics was in itself as representative of ancient glories as ancient philosophy, and they showed no hint of needing to demonstrate the importance of mathematics to philosophy. In so far as there was any concern to link the two, it was only to defend a vision of human learning as all interdependent. Celio Calcagnini (1479-1541), for example, suggested that

> Knowledge is all one body, which the Greeks call *paideia* and we *humanitas*… Thus the disciplines or parts of *humanitas* are connected among themselves… No one may therefore pursue physics without logic, nor logic without mathematics, nor anything without the support of rhetoric (Calcagnini, 1544, p. 23).[29]

It was, however, easy to recognise the beneficial characteristics of mathematics in its own right. In particular, it was praised for the certainty of its proofs. ‘The manifold proofs of arithmetic and geometry’, wrote Pier Paolo Vergerio (1370-1445), ‘make these sciences a delightful study, and one possessed of a special certainty…’ (Vergerio, 1918 [1472], p. 127, quoted from Rose, 1975, p. 13). The humanists recognised the pedagogical implications:

> Geometry ought to be studied at an early age for it sharpens the intellect and makes the mind quick at perceiving… It is fitting for the prince to be instructed in both geometry and arithmetic… Besides there is much *eruditio* in it and it produces much caution, since very often mathematics denies what is conceded by dialectic… Astronomy reveals the secrets of the heavens and its study must not be withheld from the prince.[30]

If Fernel shared these same humanist attitudes to mathematics, however, it is certain that he also knew the cautions against mathematics which could also be found in humanist writers. In particular, the humanists seemed to be well aware that, although a knowledge of mathematics could be highly useful, it was possible to go too far, and become lost in a world of utter abstraction. Indeed, this belief was expressed by two of the ancient sources for the humanists’ admiration of mathematics, Quintilian and Cicero. Quintilian’s *Institutio oratoria* (I, 10) and Cicero’s *De officiis* (I, 6) both cautioned that too much immersion in mathematics could be a distraction from the *vita activa* required of the good citizen. For Aeneas Sylvius Piccolomini, writing in 1450,

> though these [mathematical] sciences are all delightful and useful to comprehend, still I could not urge too much expenditure of time upon them,

> because advantageous as they are for the transient student, they can be harmful for a visitor who stays too long (Piccolomini, 1940, p. 123).

Similarly, Roger Ascham, in 1563 insisted that,

> Some wittes, moderate enough by nature, be many tymes marde by over much studie and use of some sciences, namelie, Musicke, Arithmetick, and Geometrie. Thies sciences, as they sharpen mens wittes over much, so they change mens maners over sore, if they be not moderatlie mingled, & wiselie applied to some good use of life. Marke all Mathematicall heades, which be onely and wholly bent to those sciences, how solitarie they be themselves, how unfit to live with others, & how unapte to serve in the world (Ascham, 1904, p. 190).

Ascham even goes so far as to say that such unfortunate cases are 'knowen nowe by common experience' (Ascham, 1904, p. 190). If this was so, then it is evident that by the late sixteenth century there were significant numbers of mathematicians who had failed to heed the warnings and had become such solitary figures, unfitted for society.

It seems, then, that Fernel could hardly have been surprised to hear his father-in-law announcing that 'mathematics is in itself as culture well enough, and exercises the wits, if one uses moderation in the time given to it. But it becomes a scandal when an honest man, with duties to the public, and his family reposes, so to say, to sleep on the quick-sands of the sirens'. His wife's father was drawing from the same humanist literature to criticise mathematics that Fernel used to defend it, and he was adding nothing new to these age-old strictures. Similarly, Fernel would not have been surprised had he seen Plancy's later description of him as 'fascinated' by mathematics, and 'caught in the toils of an enduring and delighted slavery' which held him 'in bondage and serfdom' (Sherrington, 1946, pp. 154, 153; Fernel, 1607, *6*r*).

Indeed, it was perhaps Fernel's own admiration for the humanists and their values that enabled him to recognise that he was in danger of becoming the kind of solitary thinker they warned against.

It should not be supposed, either, that when Fernel's father-in-law dismissed the utility of mathematics as of little consequence ('Apart from a modicum of arithmetic and geometry it touched society little or not at all'), he spoke merely from ignorance. For one thing, we should not forget that the words attributed to the father-in-law must have been reported to Plancy by Fernel himself, during the last ten years of his life, and some twenty years or so after the incident. In a sense, what we are reading is not so much a specific utterance by one man but a reconstruction (by Fernel when he reported it to his secretary in recollection, and subsequently by Plancy, when he came to write Fernel's *Vita*) of the kind of arguments familiarly used by the learned against mathematics. To support the suggestion that late Renaissance thinkers did not always see the practical usefulness of mathematics, we need look no further than Francis Bacon. Here was a thinker whose historical reputation rests to a large extent on the fact that he saw, when others did not, that knowledge of the natural world should *not* be regarded as knowledge for its own sake, but should be put to use to improve the lot of mankind. As is well known, however, Bacon never considered that mathematical knowledge had a major role to play in his vision for the betterment of our lives.

Again, this cannot be put down to an unfortunate oversight on Bacon's part; something that he overlooked but would have seized upon (we can suppose) had he seen it. Bacon did discuss mathematics in both the initial *Advancement of Learning* (1605) and its expanded version, *De dignitate et augmentis scientiarum* (1623), but the only use for it that he seems to have recognised, as the humanists had before him, was in pedagogy, for sharpening the wits and aiding concentration (Gaukroger, 2001, pp. 20-27). It is worth remembering also that Bacon's father, Sir Nicholas, was involved in the plans to reconstruct Dover harbour in the 1570s, and was involved in the appointment of some of the leading English mathematicians who worked on the project as surveyors, engineers, and architects. Furthermore, Sir Nicholas himself showed a strong personal fascination with mathematics.[31] Francis could hardly have missed the practical importance to England of what was, after all, the largest civil engineering scheme in Elizabethan Britain, particularly in view of his father's personal involvement, and yet when he came to develop his own ideas about how knowledge of nature could be put to use for the benefit of mankind, he gave no thought to a role for mathematics. It seems that the separation between mathematics and natural philosophy was still so effective, in the early decades of the seventeenth-century, that it was easy for Bacon to disregard mathematics while he was seeking to reform natural philosophy. Bacon wanted to reform natural philosophy to make it not only more authentic than Aristotelian natural philosophy, but also more useful. It is clear from his writings that the model he had in mind for useful natural knowledge was not mathematics, however, but natural magic (Rossi, 1968; Henry, 2002). Knowledge of supposed magical influences and interactions between things was always seen as something to be exploited for pragmatic benefits, and after the Renaissance recovery of the *Corpus Hermeticum* and other supposedly magical ancient writings such magical knowledge came to be regarded as part of the true ancient wisdom or philosophy.[32] It would have seemed natural to Bacon to look to the newly revived magical tradition, therefore, as a way of reforming natural philosophy. The same could hardly be said of mathematics. Because mathematics did not, and could not, offer causal explanations of natural phenomena, Bacon could, and did, dismiss it as irrelevant to his purposes.

Given the background that we have been surveying, a background which coloured nearly everyone's perception of mathematics from before Fernel's time through to Francis Bacon's and even beyond (many, after all, were still puzzled by the title of Newton's great book when it appeared in 1687—they wondered how there could be 'mathematical principles' of natural philosophy), it is hardly surprising that Fernel's family, and other members of his household, such as Guillaume Plancy, should regard mathematics as a largely futile and sterile occupation. Irrespective of the innovatory work of men like Regiomontanus, Copernicus, Lefèvre d'Étaples, Fine, and many others who are now recognised by historians as greater or lesser contributors to the 'mathematization of the world picture', for most learned men, as for Fernel's father-in-law, 'Mathematics made no contribution to the public weal', and 'Apart from a modicum of arithmetic and geometry it touched society little or not at all' (Sherrington, 1946, p. 154; Fernel, 1607, sig. *6*r*).

Conclusion

If Fernel was finally aroused from his slumbers on the quick-sands of the sirens by the distress of his wife and the anger of his father-in-law, and began to realise that he must choose a more suitable profession than that of mathematical practitioner, he did not need to look far. Fernel was, as we have seen, undertaking his mathematical work at the same time that he was training to be a physician. He completed the four-year curriculum leading to his MD in about 1530, and so in 1527 and 1528, the years he published his mathematical works, he must have been trying to combine his medical studies with his own commitment to mathematics. It was an easy matter, therefore, for

Fernel to simply concentrate on medicine. Indeed, the impression Plancy's *Vita* presents is that Fernel resisted a medical calling during the time when he tried to establish a career as a cosmographer. Having abandoned mathematics, however, Fernel soon rose to become the most admired physician in France and one of the most admired throughout Europe.

Nobody was ever in any doubt of the usefulness of medicine to society, of course, but it also had the advantage over mathematics that it was always perceived to go hand-in-hand with natural philosophy. Even Aristotle was said to have declared medicine and natural philosophy to be sisters.[33] Certainly, Fernel's own medical works paid a great deal of attention to natural philosophical considerations. His first major work (although withheld from the press until after he had published subsequent works), *De abditis rerum causis* (Paris, 1548), was divided into two parts, the first explicitly dealing with natural philosophy and the second with medicine. His earliest published work, *De naturali parte medicinae* (Paris, 1542), later became known simply as the *Physiologia*. This later title appropriated a term that usually referred to the whole of natural philosophy, and turned it into a term having reference only to the natural workings of the human body. Again, this suggests Fernel's own belief in the close interconnectedness of natural philosophy and medicine (Fernel, 2005, pp. 3-4). This traditional alliance between medicine and natural philosophy may not have been much of a consideration for practising mathematicians, but in the eyes of most educated men it is likely to have ensured that medicine was regarded as more intellectually and culturally significant than mathematics. We can see this even in the reported speech which Plancy attributes to Fernel's father-in-law. 'On the other hand', he says to his son-in-law after insisting mathematics touches society hardly at all, 'when we turn our gaze to medicine we find it a science occupied either with sublime enquiry into Nature or with deeds of beneficence and utility. It is of right the worthiest of all the arts.' Medicine is not just pragmatically useful but leads to a real understanding of the natural world. It was to be a very long time indeed before mathematics would be seen by educated persons routinely to have the same relevance to our understanding of nature. In the meantime, medicine remained the indispensable companion of natural philosophy, and Fernel's father-in-law spoke for a number of succeeding generations when he said that 'Mathematics offers no comparison with it' (Sherrington, 1946, p. 154; Fernel, 1607, sig. *6*r*).

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NOTES

[1] Westman 1980; Jardine, 1988; De Pace, 1993; Høyrup, 1994; Dear, 1995; Mancosu, 1996.

[2] Sherrington (1946); the editor's introduction in Fernel (2003), pp. 1-12; Siraisi (2007), pp. 122-25.

[3] There is another early source, published before Plancy's *Vita*, but it is shorter than Plancy's and generally assumed to be based on access to a manuscript copy of Plancy. It appears in Thevet, 1584. On this and other early biographies, see Sherrington, 1946, pp. 148-9.

[4] Sherrington, 1946, provides a complete list of editions of Fernel's works, pp. 187-207.

[5] There were, of course, other innovators in the medical sciences in this period, particularly in the field of anatomy (Vesalius, Fabricius, etc.), but only Paracelsus, Fracastoro, and Fernel deliberately tried to develop a new theory of health and disease, intended to go beyond the prevailing Galenic theory.

[6] On Paracelsus, see Pagel, 1958; Weeks, 1997; Grell, 1998. On Fracastoro, see Di Leo, 1953; Peruzzi, 1995. On Fernel, see Figard, 1903; Sherrington, 1946; and the editors' introductions in Fernel, 2003 and 2005. See also the special issue of the journal, *Corpus*, devoted to Fernel: Kany-Turpin, 2002.

[7] The quotation is from Guillaume Plancy's *Vita* of Fernel, written about 1567 and first published in 1607: Guillaume Plancy, 'Ioannis Fernelii D. Medici Vita', in Fernel, 1607. A full translation of this is included in Sherrington, 1946, pp. 150-70,

and I quote from this throughout. The 1607 *Vita* is unpaginated, but for those who wish to consult the Latin, I provide the printer's signature marks in Fernel, 1607, following the references to Sherrington's translation. On Fernel's influence see Sherrington, 1946, pp. 98-146; Brockliss, 1993; Brockliss and Jones, 1997, pp. 128-38.

[8] On the associations between medicine and mathematics see, for example, Maclean, 2002, pp. 171-90. The distinguished scholar Lynn Thorndike wrote that Fernel 'continued the common medieval association of mathematics with medicine'; see Thorndike, 1941, p. 557.

[9] See Westman (1980); Feingold (1984); and Schmitt (1984).

[10] See Mahoney (1994), 12.

[11] On patronage, Dawbarn and Pumfrey, 2004; Johnston, 2006. On Galileo, Biagioli, 1993. On Descartes, for example, Gaukroger, 1995. See also, for a general survey of the different social backgrounds of mathematicians in this period, Biagioli, 1989.

[12] Although it is necessary to distinguish between different kinds of practical mathematics. Fine was evidently interested in cosmography, cartography and related aspects of the mathematical sciences, but he disdained the use of mathematics in commerce. See Davies, 1960, pp. 30-31.

[13] On Jacques Govea see Sherrington, 1946, p. 172. Jacques was uncle to the more famous humanist scholar Andreas Govea, who disputed with Petrus Ramus. I have been unable to discover anything about Martin Dolet (which perhaps explains why Sherrington makes no mention of him, in marked contrast to his treatment of Govea). Presumably he is the same Martin Dolet who published at Paris, in about 1508. It is possible that he acted as a patronage broker; this is discussed below.

[14] Practical utility seems to have been one of the two main concerns of potential patrons; the other being a concern for ostentatious or spectacular display, which would enhance the fame and prestige of the patron. For a full discussion of the nature of Renaissance patronage see Dawbarn and Pumfrey, 2004. See also, Moran, 1991. As far as I am aware there has been no previous discussion of Fernel's attempts to attract patronage.

[15] Copernicus, 1992, pp. 9-10; Vogel, 2006, pp. 479-80; Randles, 1993, pp. 69-70. There is no reason to suppose, however, that Copernicus knew of Fernel's *Cosmotheoria*.

[16] Albert van Helden says that 'all educated persons after about 1250 were familiar with the principle of nesting spheres and the cosmic dimensions derived from it' (Helden, 1985, p. 37). Unfortunately van Helden overlooks Fernel's contribution to this aspect of cosmology.

[17] For a fuller discussion of this aspect of the mathematics of proportions, see Høyrup, 1994, pp. 163-4. On the science of the good life see Jones, 2006.

[18] Fernel (1528b), sig. Aiiii*r* For a discussion of the use of proportions in medicine see McVaugh (1987).

[19] Although Plancy makes Fernel's father-in-law play the lead role here, Fernel's wife came to the fore in later accounts. Lalande, 1771, Tome I, p.189, for example, said of Fernel that 'il en auroit fait davantage si sa femme ne l'eût forcé, pour ainsi dire, à quitter l'étude stérile des Mathematiques'. It is significant for our purposes that Lalande attributes to Fernel's wife a belief that mathematics is a sterile pursuit.

[20] Sherrington, 1946, p. 4, where Sherrington tells us Fernel's books cost 5 sols each, and the two books of plates were 10 and 12 sols each. See also Sherrington, 1946, pp.

15, 188 and 189. Sherrington cites as his source, Renouard, 1526-46, p. 428, but I have been unable to check this.

[21] Sherrington, 1946, p. 160; Fernel, 1607, sig. **2*v*. Plancy is reflecting his master's views here, since the stellar causation of pestilential disease is the main theme of Fernel's *De abditis rerum causis* of 1548 (Fernel, 2005). Sherrington, 1946, fails to note this distinction between what is held to be valid in astrology and what is not, and tries to suggest (incorrectly) that Fernel, after writing the *De abditis rerum causis*, came to reject astrology *tout court*; Sherrington, 1946, pp. 33-4. For a fuller discussion of Sherrington's attitude to Fernel's astrology, see the editors' introduction in Fernel, 2003, pp. 3-4.

[22] For an excellent outline of the history of astrology, see Tester, 1987. See also Webster, 1982; Garin, 1983; Rutkin, 2006.

[23] It is generally agreed that, in spite of Osiander's intervention, Copernicus really did believe in the physical truth of his mathematically determined system. This seems evident from Copernicus's own preface, his dedicatory epistle to Pope Paul III (Copernicus, 1992, pp. 3-6), and from the response of Copernicus's friends, Georg Rheticus and Tiedeman Giese, when they heard what Osiander had done. Johannes Kepler claimed that Copernicus was the first thinker to reject the separation between mathematics and natural philosophy, but some modern scholars give this accolade to Kepler himself. See, for examples, Jardine, 1984, and Grant, 1994, pp. 38-9. It has also been suggested that Regiomontanus (1436-1476) was the first (Shank, 2002).

[24] Attention was first brought to the split between realists and instrumentalists in astronomy by Pierre Duhem, 1908, 1969. The easy distinction between natural philosophers, seeking a realist cosmology, and mathematicians offering an instrumental astronomy, has proved highly fruitful for recent historiography and

undoubtedly reflects, to a large extent, the historical reality. Attempts to challenge this view by pointing to mathematicians who were realists, do not invalidate the distinction but, rather, add to our understanding of how mathematicians moved into the realm of natural philosophy (by becoming realists, in spite of being mathematicians). See Westman, 1980; Jardine, 1984; Jardine, 1988. Similarly, the recent attempt to claim that instrumentalism was not a genuine position but should be seen, rather, as 'frustrated realism' (frustrated by inability to come up with an astronomically satisfactory realist model of the cosmos) (Barker and Goldstein, 1998), has been countered by Michael H. Shank's claim that instrumentalism (or fictionalism) was 'an actor's category in Osiander and sixteenth-century astronomy' (Shank, 2002, p.179).

[25] Westman, 1980, p. 136; Randles, 1993, pp. 69-70; Vogel, 2006, pp. 479-80.

[26] Jardine, 1988, especially pp. 693-7, which is concerned with arguments about the certainty of mathematics; Mancosu, 1996; Høyrup, 1996. Jardine and Mancosu take their lead from a series of works by G. C. Giacobbe, which first drew attention to this debate on the *Quaestio de certitudine mathematicarum*. See, for example, Giacobbe, 1972a; 1972b; 1973. See also De Pace, 1993.

[27] As one leading historian of mathematics has argued, from the late fourteenth to the mid-sixteenth century 'mathematics and formalized philosophy live largely separate lives' (Høyrup, 1994, p. 125). For another account of the severe limitations on bringing mathematics and philosophy together see Molland, 1987.

[28] Rose, 1975; Biagioli, 1989; Høyrup, 1994; Dear, 1995; Marr, 2009.

[29] I am dependent here, and in the following discussion, on the account provided by Rose, 1975, pp. 5-18. On Alberti and Pacioli, and the lack of any concern that

mathematics needed to be justified in terms of its relationship to philosophy see Høyrup, 1994, pp. 148, 154.

[30] Piccolomini, 1940, p. 210. This was originally written in 1450 as a letter of advice about the education of the young king, Ladislas V of Hungary (1440-1457). See Rose, 1975, p. 14. Essentially the same assessment of the usefulness of mathematics in education can be seen, much later, in Francis Bacon's *Advancement of Learning* of 1603.

[31] See Dawbarn and Pumfrey (2004); and Tittler (1976).

[32] See Yates, 1964, and Walker, 1972. There is an alternative account of the reasons for Bacon's inability to recognise the usefulness of mathematics, namely its association with magic. See, Yates, 1967 (reprinted in Yates, 1984). In my view the argument simply does not work, because Bacon adopted and adapted much of his philosophy from the magical tradition (see Rossi, 1968 and Henry, 2002), and so the association of mathematics with magic would not have been a reason to put him off. On the association of mathematics with magic see, for example, Zetterberg, 1980; Eamon (1983); Molland (1988); Henry (1990); and Henry (2008).

[33] See, for example, Aristotle, *Parva naturalia I*, 436a 19-436b 1. For a discussion of the belief that medicine and natural philosophy were necessary complements to one another, see Temkin, 1977, and Temkin, 1991, pp. 8-17.